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	Inventor(s)	STEPHEN R. SCHWARTZ.
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**Title of Application:**

MICROPHONE-TAILORED EQUALIZING SYSTEM

**Transmitted with the patent application are the following:**

- 2 Page(s) Transmittal form (and one copy)
- Page(s) Preliminary Amendment
- 31 Page(s) Specification (26), claims (4), abstract (1)
- 4 Page(s) Informal drawing
- 2 Page(s) Declaration and Power of Attorney (signed copies as originally filed)
- 1 Page(s) Statement Claiming Small Entity Status - Independent Inventor
- Page(s) Statement Claiming Small Entity Status - Small Business Concern

This application is a Continuation-in-Part of prior application Serial No. 09/072,412, filed May 4, 1998.

<b>Fee calculation for non-small entity:</b>	<b>No. Filed</b>		<b>No. Extra</b>	<b>Rate</b>	<b>Fee</b>
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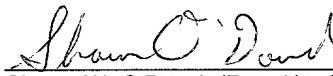
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**Respectfully submitted,**

  
Shawn W. O'Dowd (Reg. No. 34,687)  
Attorney for Applicant(s)

Kenyon & Kenyon  
333 W. San Carlos Street, Suite 600  
San Jose, CA 95110  
(408) 975-7500 - Telephone  
(408) 975-7501 - Facsimile

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KENYON KENYON

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Express Mail No. EL566657533US  
Attorney's Docket No 1158/22

**STATEMENT CLAIMING SMALL ENTITY STATUS  
(37 CFR 1.9(f) & 1.27(b))—INDEPENDENT INVENTOR**

Applicant, patentee, or identifier: Stephen R. Schwartz

Application or Patent No.: 1158/22

Filed: September 18, 2000

Title: MICROPHONE-TAILORED EQUALIZING SYSTEM

As a below named inventor, I hereby state that I qualify as an independent inventor as defined in 37 CFR 1.9(c) for purposes of paying reduced fees to the Patent and Trademark Office described in:

the specification filed herewith with title as listed above.

the application identified above.

the patent identified above.

I have not assigned, granted, conveyed, or licensed, and am under no obligation under contract or law to assign, grant, convey, or license, any rights in the invention to any person who would not qualify as an independent inventor under 37 CFR 1.9(c) if that person had made the invention, or to any concern which would not qualify as a small business concern under 37 CFR 1.9(c) or a nonprofit organization under 37 CFR 1.9(e).

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Separate statements are required from each named person, concern, or organization having right to the invention stating their status as small entities. (37 CFR 1.27)

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b)).

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

Stephen R. Schwartz

Name of Inventor

Name of Inventor  
Stephen R. Schwartz  
Signature of inventor

Signature of inventor

Sept. 18, 2000  
Date

Date

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TOTAL P. 65

## MICROPHONE-TAILORED EQUALIZING SYSTEM

### BACKGROUND OF THE INVENTION

Field of the Invention. The invention relates to microphone pickup and electronic amplification of musical instruments, particularly acoustic musical instruments, for concerts or recordings.

Background Art. Pickups for electronically reproducing sound from musical instruments are of two general types, pressure and vibration. A pressure pickup or microphone has a diaphragm that vibrates in response to acoustic pressure variations in air. The diaphragm vibrations are transformed into an electrical signal. Since the human ear also has a diaphragm that works in the same way, the acoustic response of a good pressure type microphone located at an optimal distance from a musical instrument approximates the sound of the instrument in a given room. Pressure-type microphones present problems of isolation, placement, and feedback, however.

The isolation problem results from pickup sounds from both desired sources (the instrument or instruments that one wants to amplify) and undesired sources (e.g., a cough or another musical instrument that one wishes to amplify separately). The conventional approach to minimizing the isolation problem is to place the microphone close to the selected instrument to be picked up and to use a so-called directional microphone, which attempts to reject sound from unwanted directions.

Since sound radiates by the inverse square law, moving the microphone closer to the instrument reduces the isolation problem by increasing the amplitude of sound from the selected instrument relative to the sound from other sources. This solution, however, increases the placement problem. Musical instruments generate sound from different parts, such as the strings, sound box, and front and back surfaces of a violin. At a normal listening distance from a musical instrument, the characteristic sound of the instrument is an amalgam of the sounds generated from each part.

Different spots in the area close to an instrument (especially within a foot or so) yield very different sounds, most or all of which a listener would consider unnatural. When extremely close (less than a few inches), the differences become so exaggerated that one spot sounds very different from another, and it can be difficult to tell what instrument is being listened to. Also, if the instrument is not stationary, but is held by the musician (guitar, violin, flute, etc.), small normal movements of the performer produce unintended and undesired changes in dynamic level (volume) and tone quality.

Feedback is a special circumstance arising from isolation and placement problems, typically during the types of live performance where performers hear themselves by listening to monitor speakers aimed in their direction. These speakers are thus also aimed at the microphone used to pick up the sound initially. This can create a positive feedback loop that drives the speaker amplifier into saturation, producing a loud howl. The usual corrective for feedback is to use directional

microphones, but this is of limited use. As a last resort, vibration pickups attached to the instruments themselves have been used. These pickups sense either the vibration of the instrument at the spot where they are attached (contact pickup) or the vibration of a metallic string (magnetic induction pickup) of a stringed instrument. As these pickups do not respond to the sound in air produced by monitor speakers or other musical instruments, feedback and isolation problems are greatly reduced. Also, because they are attached to and move with the instrument, the problems of changing volume and tone quality caused by a performer's movement are eliminated.

The drawback to using contact or induction pickups, however, is that the result is extremely low fidelity. The vibrations of a string or sounding board of a violin, for example, are drastically different from the vibrations of the air around the instrument. But what is defined as the "acoustic sound" of the instrument is what the ear hears as the vibration produced in the air in response to the sum of vibrations of all the instrument's parts, as described above. Thus, these transducers have been very effective in developing new electric instruments with their own sound (especially electric guitar and electric bass). However, their abilities are limited for the high fidelity reproduction of sound from acoustic instruments.

For the above reasons, current practice for electronically transducing and filtering live music from acoustic instruments is to use a quality directional microphone or microphones set up near, and aimed at, a single instrument or group of instruments. These microphones send their signal via a special cable

to a special pre-amplifier (which sometimes sends power to the mic). This then connects to general purpose equalizer and mixing circuits. For example, in a rock band a typical drum set (five drums, one hi-hat, and two cymbals) may have one directional microphone for each drum and the hi-hat, mounted on a stand very close to the drum, plus two "overhead" directional microphones for stereo effect and to pick up the cymbals. The two overhead microphones must be at least a foot or so from the cymbals to avoid picking up a loud metallic hum. A guitar may have one or two of these mics placed between one and three feet away.

As previously mentioned, it is also common to mount pickup devices directly on individual instruments, typically guitars, to produce a different type of sound from that produced by the conventional "acoustic" form of the same kind of instrument. These pickups sense the vibration of some part of the instrument, such as the strings of a guitar. Examples of such pickups are described in U.S. Patents No. 4,051,761 of Nylen, No. 4,143,575 of Oliver, No. 4,423,654 of Yamagami, No. 4,481,854 of Dugas, No. 4,837,836 of Barcus, No. 5,136,918 of Riboloff, and No. 5,206,449 of McClish. The amplified sound from these vibration sensitive pickups mounted on either acoustic or so-called electric or electronic instruments differs intentionally from the sound produced by acoustic instruments and sensed by pressure type microphones mounted at a distance from the instrument; so these vibration pickups are not suitable for high fidelity electronic reproduction of the sound of an acoustic instrument.

While references have been made to the relative low fidelity of microphones that include transducers other than air-pressure devices in the prior art, it is possible to greatly improve their quality using the methods and embodiments taught in the Summary of the Invention and Detailed Description sections below. Additionally, a combination of sensor types may provide certain advantages.

It has been proposed to mount miniature pressure-sensitive microphones directly on musical instruments for specific purposes. For example, U.S. Patent No. 4,837,836 issued to Barcus on June 6, 1989 addresses the drawbacks of using stationary conventional microphones to pick up musical instruments in general, and also of holding a standard full size microphone close to, or attaching a miniature microphone directly to, an accordion or harmonica in particular. These drawbacks include feedback from nearby speakers and undesirable emphasis of the sounds coming from a localized portion of the elongated reed banks of accordions and harmonicas; that is, an increased volume of the notes whose reeds are near where the microphone is attached.

To overcome the drawbacks of the prior arrangements, Barcus provides a pickup module in which a miniature pressure-type microphone capsule is embedded. The module has an elongated narrow sound guide channel extending between oppositely facing open ends, and a sound sensitive surface area of the microphone communicates with the central region of the channel. The narrow sound channel creates a two-lobed directional sensitivity pattern for the microphone in an attempt to respond more equally to all notes when the module is

centrally mounted on an elongated reed bank of a harmonica or accordion. Barcus also suggests that the module may be used with other musical instruments, and specifically that it can be attached to a drumhead near the edge of the drumhead to avoid feedback, pickup of an undesirable amount of room ambience, and lack of presence that occur with a conventional microphone stationed in front of the drum.

This lack of presence, a subjective term often used to describe a characteristic frequency band (which is different for each sound source), has not been noticed by the present inventor. However, in trials by the inventor using a variety of shapes, it has been noticed that strong, unnatural (and unpleasant) sounding frequency peaks are created by the shape of the cavity surrounding the microphone. These shaped microphone enclosures invariably add more problems than are solved in efforts to replicate the instrument's acoustic sound. The Barcus patent has a chart that looks like it may show improved frequency response, but it only shows improved evenness of volume from note to note. Test results of the inventor show each note would have a seriously degraded frequency response when compared to a high fidelity reference.

U.S. Patent No. 5,262,586, issued to Oba et al. on November 16, 1993, discloses a sound controller for an acoustic musical instrument to modify the sound produced by the instrument. In an example using a piano, the output of a detecting unit having 1) vibration sensors attached to the bridges and agraffes, 2) electromagnetic pickup units close to the strings, and 3) microphones attached to the sound board is delivered to a digital processing unit. Processors actuated by

the various types of sensors for controlling loudness, delay, equalization, and phase difference deliver their output to vibration actuators mounted on the sound board and case boards of the piano. A parameter determining means adjusts the various processors so that the actuators create additional vibrations to produce acoustic sounds with modified qualities. Thus, Oba et al. use microphones as one of several types of pickups mounted inside a musical instrument to feed sounds and vibrations generated by playing the instrument to a vibration unit that alters the acoustic output of the instrument. Oba et al. do not use these microphones to produce an electronic signal in response to the acoustic output of the instrument for recording or amplifying the unmodified output. Consequently, none of the arrangements of the prior art provides a high fidelity solution to the problems of microphone isolation and placement encountered in electronic reproduction of sound from an acoustic musical instrument. Each case is currently successful only via careful tailoring by a sound engineer using sophisticated equipment.

#### SUMMARY OF THE INVENTION

The present invention provides a method for designing a system (microphones, attachment mechanisms, and associated preamplifiers and equalizers) to be used with solo or group musical instruments, and the system as designed by the method. A principal feature of the system is the use of one or more microphones placed proximately to, on or inside an instrument. For example, the microphone can be mounted permanently on or in the instrument, or it can be attached temporarily to the instrument with a clip designed for the specific instrument in question. It may also be held on a stand when feasible and

preferable. While any mic of suitable quality will do, a miniature microphone (and particularly when attached to the instrument) has two advantages. First, it is easier to accurately place, and will go in some places that a normal microphone will not fit. Second, it will move with a non-stationary (e.g., hand-held) instrument, and so avoid unwanted changes of sound quality that arise when an instrument moves relative to a microphone. As used herein, one skilled in the art will appreciate that the term "microphone" includes a variety of devices such as air pressure sensors, vibration sensors, and magnetic sensors. A microphone may also include other types of sensors such as light and heat sensors or combinations of the aforementioned sensors.

A further feature of the system is a suitably designed microphone preamp connected in tandem with and closely positioned (less than eight meters and preferably 3 to 6 meters) to at least one microphone. The microphone preamp delivers dc power to the microphone (if needed) as well as receiving, and initially amplifying, the audio signal from the microphone.

Another feature of the system is an equalizer unit that is "tailor-made" for each type of instrument and, more particularly, for a preselected optimum microphone location on each type of instrument. The equalizer may include conventional low pass, high pass, band pass, or notch filters, as appropriate. Contrary to conventional general purpose equalizers having four or more adjustable filters, with up to three controls for each filter (a total of twelve or more knobs), these units may have only a minimum number and type of filters needed to compensate for the differences between the

instrument's sound at a normal listening spot and the microphone attachment spot. Each filter control can be limited to the smallest useful range that allows enough flexibility for variations between individual instruments.

Each equalizer can be combined with a preamplifier in a small, lightweight package that can be mounted close to the performer. This allows the individual musicians to achieve their own preferred "sound" without needing a skilled audio technician to make complex multiple adjustments at a master equalizer console.

These features of the system sharply reduce the cost of the audio input equipment for a band or orchestra and dramatically shorten the time required to set up the equipment for a concert or recording session. They also enable a musician or other person to accomplish what is presently achievable only by a sound engineer.

As used herein, the term "reference sounds of the instrument" means sounds produced by the instrument that are desired to be duplicated in quality by the attached microphone and tailor-made equalizer. In its simplest form, it means the sound of an instrument being played and listened to in its normal environment (but generally exclusive of the room's influence on the sound). For example, if a guitar player plays a guitar in a pleasant and dry (non-reverberant) sounding room, the "reference sounds of the instrument" would be the acoustic signature of the sound at a good/normal listening position in that room. A second reference method is when a high quality reference microphone is used to capture this sound, and a third

reference method is when the microphone signal is recorded on a hi quality storage device (such as a digital tape recorder).

When using a microphone reference, the listening site preferably is spaced from the instrument a sufficient distance to permit the reference microphone to pick up the optimum sound quality of the instrument (generally, a distance from the instrument equal to the width of instrument). This spot also should avoid the sound of the room. The room itself should be made to contribute minimally to the sound received at the microphone(s). A common terminology for this is to say the mic is placed in a mid-field position, and the room is dry or damped (literally = "discouraged"). An anechoic chamber is an ideal room, as it would make certain aspects of the design process easier and perhaps more accurate. However, these rooms are rare and very expensive, and not necessary to the method.

Specifically, the present invention provides a method for designing a system for high fidelity reproduction of the sound of a selected type of acoustic musical instrument, and also for providing embodiments of the system, the method comprising:

- (1) placing a first microphone proximately to the acoustic musical instrument;
- (2) playing the musical instrument to produce sounds as picked up by the first microphone and playing reference sounds of the instrument;
- (3) comparing the sounds of the musical instrument as picked up by the first microphone with the reference sounds of the instrument; and
- (4) designing a tailor-made equalizer to compensate for the differences between the sounds as picked up by the

microphone and the reference sounds of the instrument.

The method of the invention may additionally include:

- selecting an attachment location in step 1 by locating the first microphone successively at a plurality of possible attachment locations that do not interfere with playing the instrument,
- playing the instrument to produce reference sounds of the instrument,
- comparing sounds as picked up by the first microphone at each attachment location with the reference sounds of the instrument, and
- selecting the attachment location at which the amplified microphone sound is closest to the reference sound of the instrument.

Although the step of comparing the sounds picked up by the first microphone with reference sounds of the instrument can be made by listening directly to the two sounds, a preferred embodiment of the method comprises:

- (1) placing a first microphone proximately to the acoustic musical instrument;
- (2) positioning a high quality reference second microphone at an appropriate listening site (normally mid-field, as discussed above) for the acoustic musical instrument;
- (3) playing the musical instrument to produce reference sounds of the instrument as picked up by the reference second microphone;
- (4) making simultaneous first and second audio recordings of the sounds of the musical instrument as picked up by the

respective first and second microphones;

(5) comparing the first and second audio recordings to determine the audio differences between the recordings; and

(6) designing a tailor-made equalizer for the first microphone to compensate for the differences of the first sound recording from the second sound recording.

The method of the invention may further include repeating the above steps (1) through (5) using different musical instruments of the same type to determine adjustment ranges for sections of the equalizer designed in step (6).

The fourth step of making simultaneous first and second audio recordings preferably can include making multi-track recordings on a digital or other high quality recording medium.

The fifth step of comparing the first and second audio recordings preferably includes displaying and analyzing acoustic waveforms of the first and second recordings; equalizing one of the first and second waveforms to substantially conform to the other waveform; and using the equalization values to design the tailor-made equalizer for the first microphone in step (6).

The present invention also provides a system for high fidelity electronic reproduction of the sound of an acoustic musical instrument, the system comprising:

a microphone element or elements;  
microphone attachment devices, where suitable or advantageous;

an equalizer having an input coupled to the microphone, the equalizer including a predetermined minimum number of electronic filter circuits, controls, and control ranges optimized to compensate for differences in the electronic reproduction by the microphone element, of sounds from the preselected type of acoustic musical instrument compared with corresponding reference sounds from the type of musical instrument.

The mounting device may also include a device for removably attaching the microphone to the instrument, the device being specifically designed for attachment at the preselected location on the particular instrument so as to avoid or minimize altering the sounds produced by the instrument and to enable a performer to play the instrument unencumbered.

The equalizer may comprise one or more electronic filter types, depending on the type of musical instrument. For example, a tailor-made equalizer for acoustic guitars has a high-pass filter and two notch (band-reject) filters. A tom-tom drum equalizer has one high-pass filter and one low-pass filter. A bass drum equalizer has three high-pass filters and one low-pass filter, with a total of five controls. Hi-hat and cymbal equalizers have only a high-pass filter in series with a single notch filter, but with three controls.

The above-described and other features and advantages of the invention are presented in the drawings in connection with the detailed description of the preferred embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a general block diagram of an equalizer system designed according to an embodiment of the present invention.

FIG. 2A is a general block diagram of an equalizer for a miniature microphone attached to an acoustic guitar;

FIG. 2B is a schematic diagram of the circuit of FIG. 2A;

FIG. 3 is a block diagram of an equalizer circuit designed according to an embodiment of the invention for a bass drum;

FIG. 4 is a block diagram of an equalizer circuit designed according to an embodiment of the invention for a snare drum;

FIG. 5 is a block diagram of an equalizer circuit designed according to an embodiment the invention for a tom-tom.

DETAILED DESCRIPTION

According to the present invention, the microphone assembly includes a microphone such as an omnidirectional or unidirectional microphone element, such as a Model No. DPA 4060 microphone manufactured by Brüel and Kjaer. The microphone element can be attached to a clip or housing to permit for temporarily attaching the microphone assembly to a pre-selected spot on or in an acoustic musical instrument. Other temporary attachment arrangements may be provided when necessary. The

clips or other attachment devices are selected to minimize mass loading of the instrument structure to which the microphone is attached. In some cases, permanent attachment of the microphone assembly to a specific musical instrument by suitable means may be acceptable. Alternatively, the microphone can be placed proximately to the musical instrument rather than being attached to the musical instrument.

Referring to Fig. 1, a general block diagram of an equalizer system is shown constructed according to an embodiment of the present invention. Block 10 represents an instrument such as the instruments described below. Sounds generated by instrument 10 are picked up by a microphone 11 (e.g., attached to the instrument). The sounds picked up by microphone 11 are provided to a microphone power supply (if needed) and amplifier 12 and a specialized processor 13 (e.g., a tailor-made equalizer as described below). The output of the specialized processor 13 is then provided to an appropriate output device 14 such as a recording device a public address (PA) system, a speaker system, etc.

In practicing the method of the invention for designing a tailor-made microphone and equalizer system for a specific type of acoustic musical instrument, the first step is to place a microphone proximately to the instrument. Alternatively, the microphone can be attached to a location on or in an instrument of the selected type. The placement location is preselected with a view to sensing an airborne acoustic signature that is as little different as possible from the acoustic signature of the instrument when heard or sensed at a normal listening site spaced from the instrument. The term "listening site" refers

either to a location for a human auditor or to a location for placement of a reference microphone to pick up sound for amplification.

What constitutes a normal listening site includes how much, if any, "room sound" (i.e. reverberation) is desired. The sound of an instrument differs in each room, and even varies significantly from place to place in a given room. Acoustic engineers designate a location where the sound of an instrument is augmented by room sound as the "far field" and a location where the sound of an instrument is substantially unaffected by room sound as the "mid field" or "near field."

In some recording or broadcast situations, with an instrument ensemble or orchestra in an exceptionally nice sounding environment such as Carnegie Hall, using microphones in the far field to involve the sound of the room can produce excellent results, so long as no sound reinforcement is required. Most often, however, room effect is undesirable, since a poorly selected listening site can produce results worse than having no room sound at all. In an anechoic chamber, or even a heavily draped and carpeted room, reverberation is essentially eliminated and there is no room sound, regardless of listening location. To eliminate the effect of room sound on the sound of an acoustic instrument without the expense of an anechoic chamber, it has become the norm in both the sound-reinforcement and recording and broadcast industries to use unidirectional microphones placed in what is called the mid field. The microphone is placed far enough away to get the natural sound of the entire instrument, but as close as possible to avoid the sound of the room. This

distance is generally about the same as the average dimension of the instrument or a group of instruments.

Because unidirectional microphones reject only a portion of sound coming from unwanted directions, and because some unwanted sound comes from behind the instrument, a significant amount of room and other sound may be still picked up at a mid field listening position. To eliminate this, a microphone is placed in the near field, spaced about zero to twelve inches away from the instrument. This is known as "close micing." This strongly increases the ratio of instrument sound to room and other sound, because of the inverse square relation of distance from source to energy of sound. Close micing produces a less natural sound than listeners are used to, however; even the ears of the musician playing the instrument are further away than the close mic in most cases. Various processing equipment is usually needed to improve the nature of close-miced sound. The present invention improves and optimizes this, as shown below. It should be noted that for some instruments, however, particularly drumset components and certain vocal styles, a "close mic" sound has become the musical norm because the most common listening experience of these instruments has been a close-miced recording or performance. If close micing becomes more widely used, other instruments may have their 'sound' defined this way.

For most purposes, it is desirable to have a listening room comparable in equipment and sound characteristics to a professional recording studio. The following equipment list is given by way of example:

Unidirectional dynamic reference microphone (RefMic 1) -  
Sennheiser Model MD441 super-cardioid dynamic;  
Unidirectional condenser reference microphone (RefMic 2) -  
Neumann K150 hyper-cardioid condenser;  
Omnidirectional dynamic reference microphone (RefMic 3) -  
Sennheiser Model MD211 dynamic;  
Microphone preamplifier (Mic Preamp 1) - John Hardy Model  
M1;  
Microphone preamplifier (Mic Preamp 2) - Symetrix Model  
201;  
Parametric equalizer (EQ 1) - Orban Model 621B (four bands  
per channel);  
Parametric equalizer (EQ 2) - Symetrix Model SX201 (three  
bands per channel);  
Graphic equalizer (EQ 3) - DOD Model R-231 (one-third  
octave per band, 31 bands per channel);  
Monitor amplifier (Amp) - Macintosh Model 6200;  
Small near field monitor speaker (Spkr 1) - Rogers Model  
LS3/5A, BBC near field reference standard;  
Large monitor speaker (Spkr 2) - Tannoy Dual-Concentric  
12-inch, tuned to room with UREI Model 539 Room  
Equalizer;  
Mixer (Mxr) - Hill Model B3 24x8x2 (uses 5532 operational  
amplifiers);  
Multi-channel audio tape recorder - Alesis Digital Audio  
Tape (ADAT) multi-channel recorder, run at 48 kHz;  
Real Time Analyzer (RTA) - Audio Control Model SA-3050A  
one-third octave with calibrated microphone (ANSI  
Class S1.11-1971)

The above list is not exhaustive, and the choice of

manufacturer and model in each case is not intended to be exclusive. Other makes and models of comparable or better quality may be used.

The choice of a reference microphone depends on the choice of listening site. Repeated comparisons between a condenser microphone (RefMic 2) and several dynamic microphones (RefMic 1) rarely showed significant differences, however, and it is usually sufficient to use a RefMic 1.

As stated in the summary of the invention, the term, "reference sounds of the instrument," means sounds produced by the instrument that are desired to be duplicated in quality by the attached microphone and tailor-made equalizer. The quality or nature of sounds produced by the instrument will be different, however, for different rooms and for different placements of instrument and listener in a given room. Thus, the "reference" sounds used as a standard of comparison necessarily will involve subjective choice (this is true for all musical reproduction), but this subjectiveness is minimized by using a high quality (usually directional) microphone at a proper (usually mid-field) distance from the instrument in a room with minimal reverberation or other sound components. An anechoic chamber (rarely available) would be an ideal place for this purpose.

The step of playing the musical instrument to produce sounds as picked up by the first microphone and also reference sounds requires a skilled musician to play, with consistent volume and tone quality, a series of notes chords, and musical phrases, as appropriate, to produce musical sounds

representative of the full range of the instrument. As the musician plays, each note and chord is picked up by the first microphone, which may be coupled through a suitable preamplifier (e.g., Mic Preamp 1 or Mic Preamp 2), a conventional professional quality equalizer (e.g., EQ 1, EQ 2, or EQ 3), and an amplifier (Amp) to a monitor loudspeaker (e.g., Spkr 1 or Spkr 2) or to headphones, as desired. The musician produces the reference sounds either simultaneously or alternately with the corresponding sounds picked up by the first microphone, depending on which of several possible ways the comparing step is to be performed. As indicated above, the reference sound may be the acoustic sound of the instrument heard at the listening site or may be picked up by a reference microphone at the listening site that approximates an average "ideal" acoustic sound. (For comparison purposes, it may be processed through amplifying and equalizing equipment similar to that used with the first microphone.)

The step of comparing the sounds of the musical instrument as picked up by the first microphone with the reference sounds of the instrument may be performed in several ways. Each way preferably entails a skilled audio engineer, or equivalent in training, making the comparison between the two sounds and adjusting a conventional equalizer to bring one sound into conformance with the other. It is well recognized in the audio engineering art that a skilled engineer or audio technician can discriminate between the acoustic signatures of similar sounds at least as well as any currently available audio test equipment. The following excerpts from articles in "Handbook for Sound Engineers - The New Audio Cyclopedia," 2nd edition, Glen Ballou, ed. (1991, H. W. Sams and Co., Div. Of Macmillan,

Carmel IN) make this clear:

- (Pg. 253) F. Miller: "The very best piece of test equipment you own is your set of ears and good judgement."
- (Pg. 501) C. Hendrickson: "Some users or evaluators of sound equipment are actually capable of making judgements merely by listening to the sound quality of a loudspeaker with music or voice signals being the input. This is actually a learnable art and discipline."
- (Pg. 1408) D. & C. Davis: "walking the audience areas while using the most sophisticated analyzer available, namely the trained ear-brain system, determine the best areas and the worst areas. Then measure [with equipment] in the best areas for reference use and the worst areas for correction purposes. Watching an engineer place a measuring microphone relative to a given situation is more revealing than any resume of his experience."

While examples of analysis and/or design are described herein for a human operator/technician, both the analysis and design can be aided by the use of a computer or other machine. Such a machine may accomplish the analysis and/or design without any direct human involvement. For example, a machine may be designed using the teaching herein to fine tune a unique equalizer system to a specific individual instrument (as opposed to a more general instrument type as discussed) at the point of sale of such a system, without the need for a trained technician to do so.

In the simplest performance of the comparison step, the

sound signal delivered by the first microphone to either a monitor loudspeaker or an earphone can be compared directly and simultaneously with the sound received acoustically by an audio engineer stationed at an equalizer located at the listening site. During repeated playings of a specific note or chord, the engineer adjusts the equalizer to bring the sound from the first microphone into coincidence with the reference sound heard directly.

An advantage of this way of comparing the sounds is that the reference sound is the true acoustic sound transmitted from the instrument to the listening site, unaffected by translation to and from electronic form. This way also presents several disadvantages, however. These include:

If two sounds are played together, they produce a single combined sound, and thus color each other, so it is nearly impossible to compare and equalize two simultaneous sounds. They must be listened to one at a time, which means comparing the sound being listened to with a REMEMBERED sound; this is much less accurate than a direct comparison back-and-forth.

It may be desirable, for some applications, to provide a reference sound that differs from the pure acoustic signal delivered from the instrument to the listening site. The sound of a drumset and the sound of certain vocal styles are common examples where the placement of a mic combined with the process of electronic modification has become the MUSICALLY accepted standard of sound.

The preferred way of comparing the two sounds, therefore, is to simultaneously pick up and record the acoustic sound of the instrument with a second, reference microphone placed at the listening site. To obtain a complete record, the instrument should be played through a succession of notes and chords covering its full range, along with representative musical excerpts. This entire process is repeated with several instruments of the same type to be sure that differences in individual instruments are accounted for and will work within the final design parameters. The output of the reference microphone may be passed through a conventional studio-quality mixer or equalizer bank that is adjusted to create a compensated reference sound that, when fed to an amplifier and monitor speaker or headphones, produces an audio output that is identical, or as close as possible, to the direct unamplified sound of the musical instrument, or when different, is close to a reference sound desired in common practice. The equalizer for the first microphone may next be adjusted, through successive playings of the instrument, to bring the sound from the first microphone into conformance with the reference sound.

The settings of the equalizer for the first microphone then provide data for designing the tailor-made equalizer in the final step. Alternatively, after noting the initial settings of the equalizer for the second microphone, the technician may adjust that equalizer to bring the reference sound into conformance with the sound from the first microphone. The change in settings of the second equalizer then provides the data for designing the tailor-made equalizer of the invention.

The use of a second, reference microphone also permits a further improvement in the comparing step. Since both the sound from the first microphone and the reference sound have been converted to electronic form, they can be simultaneously recorded on separate tracks of a multi-channel tape recorder (e.g., ADAT). This has two advantages. First, the test data (notes, chord, and musical phrases) need be played only once, and then can be repeated identically again and again from the tape, as adjustments are made to the equalizer controls. This assures that the same sounds are being compared each time. Secondly, the sound from the first microphone and the reference sound can be separated and played back sequentially, which makes the task of comparing the sounds much easier. Depending whether the differences are relatively uniform through the high end or low end of the audio frequency spectrum or whether they are in one or more relatively narrow frequency ranges, appropriate high-pass, low-pass, band-pass, or notch filter circuits can be selected and combined and the component values determined by a competent technician to achieve the desired equalizer that is to be tailor-made for the selected type of instrument.

FIGS. 2A and 2B show the results of the above-described design process as applied to an acoustic guitar in which the miniature microphone assembly was attached by a special clip (not shown) to the sound-hole. In the equalizer of these figures, an input gain circuit 60 connects to a high-pass filter circuit 70 that, in turn feeds two band-pass filter circuits in series 110 and 210, which finally connect to an output amp circuit 310. Since the filters are typical of conventional textbook circuits, no further explanation of the

their operation is needed.

FIG. 3 shows a block diagram of a tailor-made equalizer, designed by the method of the invention, for a bass drum. The output from a microphone (not shown) attached to a selected location on a bass drum would be fed through a preamplifier (not shown) to a high-pass filter 32 having an adjustable lower frequency roll-off of from 25 to 200 Hz. This circuit permits cutting off the strong low frequency component of the sound from a drum of this type, which could otherwise saturate the amplifier system. From high-pass filter 32, the signal passes through high-pass filter 33 (having a low-frequency roll-off at 10 kHz), through high-pass filter 34 (with an adjustable low frequency roll-off between 160 Hz and 12 kHz), and through low-pass filter 35 (having an adjustable high-frequency roll-off ranging from 31.5 to 500 Hz). Block 36, labeled "DRY" denotes a selectable bypass path around filters 33-35, to allow a comparison with the original sound.

FIG. 4 is a block diagram of an equalizer tailor-made for a snare drum. This equalizer also has a high-pass input filter 42 with an adjustable low frequency filter leading to high-pass filter 43 (with an adjustable low frequency roll-off between 160 Hz and 16 kHz), and a low-pass filter 44 (having an adjustable low frequency roll-off between 40 and 2 kHz). As in the bass drum equalizer of FIG. 3, there is a bypass "DRY" path 45.

FIG. 5 illustrates a tailor-made equalizer for a tom-tom. This is a simple circuit having a high-pass filter 53 (with a fixed low frequency roll-off at 3.15 kHz) and a low-pass filter

54 (having an adjustable high frequency roll-off between 40 Hz and 2 kHz. As in the preceding drum equalizers, there is a bypass "DRY" path 55.

The foregoing examples of equalizers tailor-made for specific types of acoustic musical instruments demonstrate the simple, and therefore inexpensive, solution of the present invention for providing high fidelity audio reproduction of these instruments when combined with a microphone proximately placed or directly attached to the instrument.

I CLAIM:

1. A method for providing a system for high fidelity reproduction of the sound of a selected type of acoustic musical instrument, the method comprising:

(1) placing a first microphone at a selected location proximate to the acoustic musical instrument, said first microphone including at least one of an air pressure sensor, a vibration sensor, a magnetic sensor, a light sensor and a heat sensor;

(2) playing the musical instrument to produce sounds as picked up by the first microphone and playing reference sounds of the instrument;

(3) comparing the sounds of the musical instrument as picked up by the first microphone with the reference sounds of the instrument; and

(4) designing a tailor-made equalizer for the first microphone to compensate for the differences between the sounds as picked up by the microphone and the reference sounds of the instrument.

2. The method of claim 1 wherein said comparing step is performed automatically by a computer.

3. The method of claim 1 wherein in said placing step, said first microphone is attached to the acoustic musical instrument.

4. The method of claim 1 wherein the step of comparing the sounds picked up by the first microphone with reference

sounds of the instrument is made by listening directly to the two sounds.

5. The method of claim 2 wherein the step of comparing the sounds picked up by the first microphone with reference sounds of the instrument is made by listening directly to the two sounds.

6. The method of claim 1, further comprising repeating steps (1) through (3) using different musical instruments of the same type to determine adjustment ranges for sections of the equalizer designed in step (4).

7. A method for providing a system for high fidelity reproduction of the sound of a selected type of acoustic musical instrument, the method comprising:

(1) placing a first microphone to a selected location proximate to the acoustic musical instrument;

(2) positioning a reference second microphone at a listening site spaced from the acoustic musical instrument, said first and second microphones including at least one of an air pressure sensor, a vibration sensor, a magnetic sensor, a light sensor and a heat sensor;

(3) playing the musical instrument to produce sounds as picked up by the first microphone, and to produce reference sounds of the instrument as picked up by the reference second microphone;

(4) making simultaneous first and second audio recordings of the sounds of the musical instrument as picked up by the respective first and second microphones;

(5) comparing the first and second audio recordings to

determine the audio differences between the recordings; and

(6) designing a tailor-made equalizer for the first microphone to compensate for the differences of the first sound recording from the second sound recording.

8. The method of claim 7 wherein said comparing step is performed automatically by a computer.

9. The method of claim 7 wherein in said placing step, said first microphone is attached to the acoustic musical instrument.

10. The method of claim 7 wherein the listening site in step (2) is spaced from the instrument a sufficient distance to permit the reference microphone to pick up an optimum sound quality of the instrument when positioned at that site.

11. The method of claim 8 wherein the listening site in step (2) is spaced from the instrument a sufficient distance to permit the reference microphone to pick up an optimum sound quality of the instrument when positioned at that site.

12. The method of claim 7, further comprising repeating steps (1) through (5) using different musical instruments of the same type to determine adjustment ranges for sections of the equalizer designed in step (6).

13. The method of claim 7 wherein the fourth step of making simultaneous first and second audio recordings preferably comprises making recordings on separate tracks of a multi-track recordable medium.

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14. The method of claim 7 wherein the fifth step of comparing the first and second audio recordings comprises displaying and analyzing acoustic waveforms of the first and second recordings; equalizing one of the first and second waveforms to substantially conform to the other waveform; and using the equalization values to design the tailor-made equalizer for the first microphone in step (6).

15. A system for high fidelity electronic reproduction of the sound of an acoustic musical instrument, the system comprising:

a microphone element adapted to be placed proximately to a preselected type of acoustic musical instrument, said microphone element including at least one of an air pressure sensor, a vibration sensor, a magnetic sensor, a light sensor and a heat sensor; and

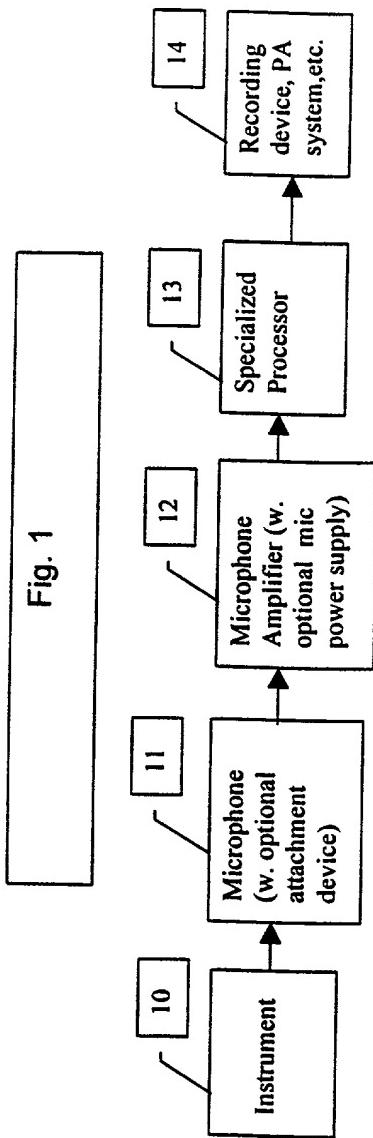
an equalizer having an input coupled to the microphone, the equalizer including a predetermined minimum number of electronic filter circuits and controls, with optimized control ranges needed to compensate for differences in the electronic reproduction by the microphone element of sounds from the preselected type of acoustic musical instrument, compared with corresponding reference sounds from said type of musical instrument.

16. The system of claim 15 wherein the microphone element is further adapted to be attached to a preselected location on the musical instrument.

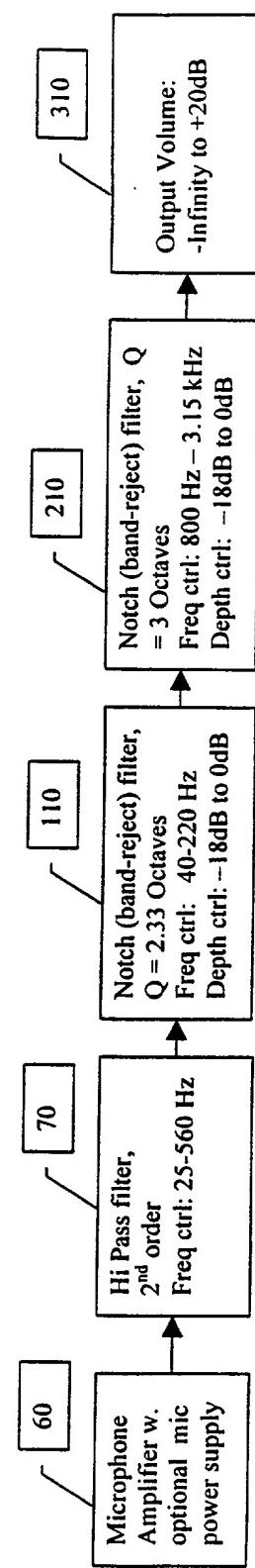
## Abstract of the Disclosure

A method and system is described to improve the reproduction of sound of an acoustic musical instrument. According to one embodiment, a first microphone is placed at a proximate location to the musical instrument to pick up the sound of the musical instrument. The sound as picked up by the first microphone is compared to a reference sound of the instrument (e.g., the sound of the instrument as perceived at a normal listening position). Based on this comparison, a tailor-made equalizer is designed to compensate for the differences between the sounds as picked up by the first microphone and the reference sounds of the musical instrument. Accordingly, using the tailor-made equalizer allows the reproduction of sound from the first microphone to have a quality similar to that of the reference sound of the musical instrument.

**Fig. 1**



**Fig. 2A**



**Fig. 2B**

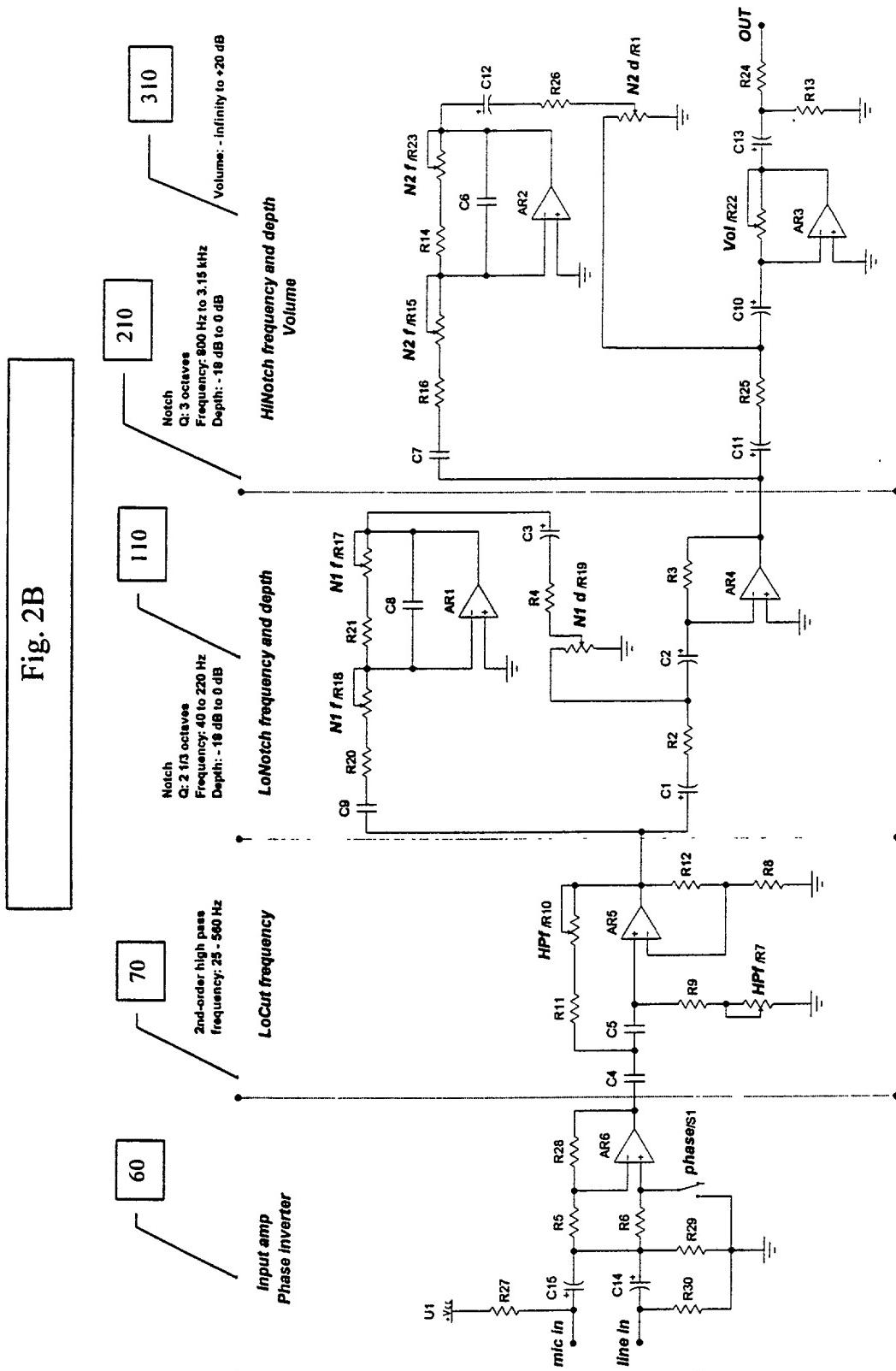


Figure 3

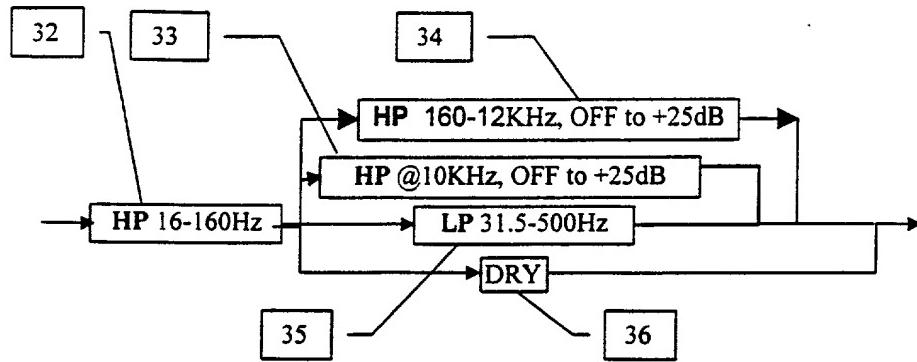


Figure 4

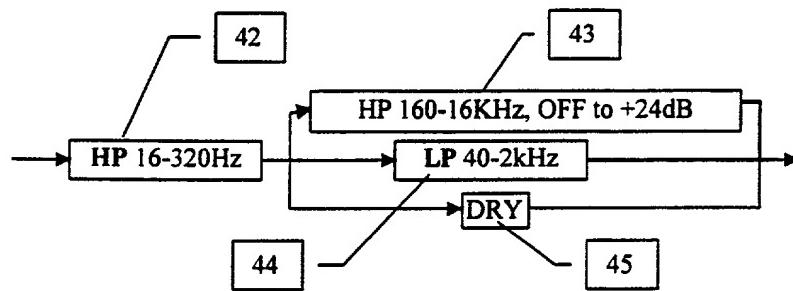


Figure 5

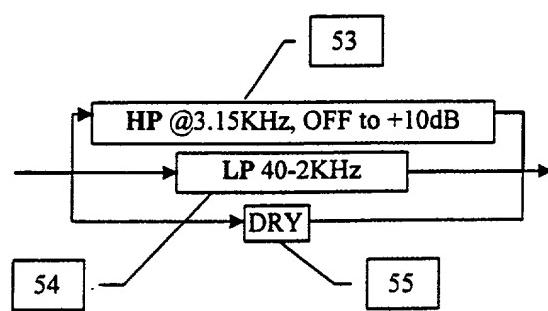


Fig. 6

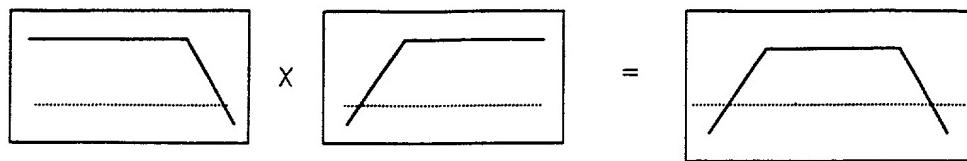


Fig. 7

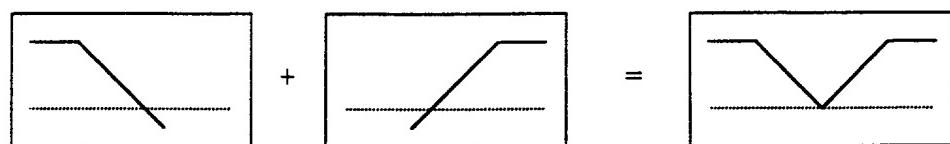
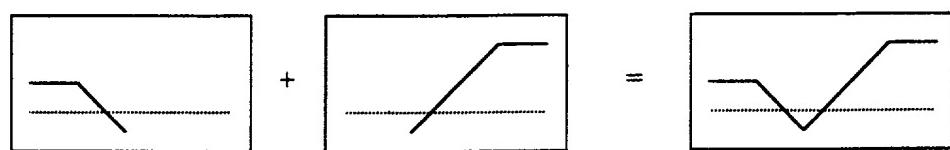


Fig. 8



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KENYON KENYON

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PATENT

Docket No. 1538/22

## DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that

My residence, post office address and citizenship are as stated below next to my name

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

## MICROPHONE-TAILORED EQUALIZING SYSTEM

the specification of which is attached hereto unless the following is entered

was filed on	as United States Application Number or PCT International Application Number	and was amended on (if applicable)
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I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR §1.58

## PRIOR FOREIGN APPLICATION(S)

I hereby claim foreign priority benefits under 35 USC §119(a-d) or §365(b) of any foreign application(s) for patent or inventor's certificate, or §365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below any foreign application(s) for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed:

Application Number	Country	Filing Date (day/month/year)	Priority Not Claimed

## PROVISIONAL APPLICATION(S)

I hereby claim the benefit under 35 USC §119(e) of any United States provisional application(s) listed below

Application Number	Filing Date

## PRIOR UNITED STATES APPLICATION(S)

I hereby claim the benefit under 35 USC §120 of any United States application(s), or §365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 USC §112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR §1.58 which became available between the filing date of the prior application and the national or PCT International filing date of this application

Application Number	Filing Date	Status (patented, pending, abandoned)
09/072,412	May 4, 1998	Pending

## POWER OF ATTORNEY

I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

John C. Altmiller (Reg. No. 25,951), Philip J. McCabe (Reg. No. 27,658), Shawn W. O'Dowd (Reg. No. 34,587) of KENYON & KENYON with offices located at One Broadway, New York, NY, 10004-1050, telephone (212) 425-7200, and at 333 W. San Carlos Street, Suite 600, San Jose, CA, 95110-2711, telephone (408) 975-7500.

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KENYON KENYON

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**PATENT**

Docket No. 1638/22

**DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION (Cont.)**

Direct telephone calls to:

SHAWN W O'DOWD  
(408) 975-7500

Send correspondence to:

KENYON & KENYON  
333 W. San Carlos, Street, Suite 800  
San Jose, CA 95110-2711

I hereby declare that all statements made herein of my own knowledge are true and all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code and that such willful statements may jeopardize the validity of the application or any patent issuing thereon.

<i>Full name of first or sole inventor</i>	Last Name <i>Schwartz</i>	First Name Stephen	Middle Name R.
Residence	City Providence	State or Country Rhode Island	Country of Citizenship U.S.A.
Post Office Address	Street 172 Congdon Street	City Providence	State or County & Zip Code Rhode Island 02906
Signature	<i>Stephen R. Schwartz</i>		
	Date		

<i>Full name of second inventor</i>	Last Name	First Name	Middle Name
Residence	City	State or Country	Country of Citizenship
Post Office Address	Street	City	State or County & Zip Code
Signature	Date		

<i>Full name of third inventor</i>	Last Name	First Name	Middle Name
Residence	City	State or Country	Country of Citizenship
Post Office Address	Street	City	State or County & Zip Code
Signature	Date		

<i>Full name of fourth inventor</i>	Last Name	First Name	Middle Name
Residence	City	State or Country	Country of Citizenship
Post Office Address	Street	City	State or County & Zip Code
Signature	Date		

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